American POTATO JOURNAL

Volume 37 *June 1960* *Number 6*

CONTENTS

Official Publication of

THE POTATO ASSOCIATION OF AMERICA

NEW BRUNSWICK, NEW JERSEY, U. S. A.

Jerry Ryan

Tom Ryan

Leading potato growers **INCREASE SPRAY EFFECTIVENESS** with **PLYAC*** Polyethylene Spreader-Sticker

Here's what they say:

"The application of insecticides and fungicides is of utmost importance in producing certified seed potatoes.

"We grow approximately 1,000 acres of certified seed potatoes annually and feature clean field readings. To do this, it is necessary to have insect control at all times to prevent the transmission of any virus to the seed plants.

"In 1959, we used Plyac in all of our sprays and feel that the increased residual and effectiveness of chemicals was well worth the nominal cost of Plyac."

Tom Ryan and Jerry Ryan
Ryan Farms, East Grand Forks, Minn.

Take a tip from well known potato growers Tom Ryan and Jerry Ryan. With Plyac spreader-sticker in your sprays you'll need to do less re-spraying . . . stretch the time between sprays . . . increase the sticking and staying power of insecticides and fungicides.

Plyac makes sprays stick better and last longer, even in rainy weather when other sprays wash off easily. Easy to use and economical, too! Plyac is a non-oil product. Comes in convenient liquid form. Add it to wettable powders, sprays and emulsifiable concentrates. Only 2 to 4 ounces are needed for each 100 gallons of spray mixture.

For increased spray effectiveness, add Plyac polyethylene spreader-sticker to *all* your sprays this season!

*Trademark of Allied Chemical Corporation

Allied Chemical

GENERAL CHEMICAL DIVISION
40 Rector Street, New York 6, N. Y.

American Potato Journal

PUBLISHED BY
THE POTATO ASSOCIATION OF AMERICA
NEW BRUNSWICK, N. J.

Price $4.00 per year in North America; $5.00 in other countries.
Not responsible for free replacement of non-delivered or damaged issues after 90 days.

Entered as second class matter at New Brunswick, N. J., March 14, 1942 under Act of March 3, 1879. Accepted for mailing at special rate of postage provided for in section 412, Act of February 28, 1925, authorized on March 14, 1928.

SIMPLE DESIGNATIONS OF POTATO-INFECTING AND OTHER VIRUSES IN ACCORDANCE WITH THE PERIODICAL SYSTEM OF PLANT AND ANIMAL VIRUS INTERRELATIONSHIPS[1]

Henning P. Hanson[2]

1. *Introduction.*

In previous papers the author has proposed a new principle in virus nomenclature (21, 22), namely a system of formulas objectively describing some essential characteristics of the individual viruses. The proposed formulary names are binominal and latinized and thus apparently similar to the usual international names of plants and animals and to the binary virus names first proposed by Holmes (29, 30).

In these names, however, the former part (the generic name) is composed of symbols for three essential and mutally independent characteristics. The symbols proposed for generic plant virus names are defined in Table 1. From this it will be seen that the three groups of symbols to be combined in generic names refer to direct transmission, to vector transmission, and to particle type. A combination of these three characteristics will clearly indicate the kind of virus in question. An additional specific epithet is then sufficient for the final identification of the virus concerned.

It is urgently necessary that viruses can be clearly distinguished and identified by their designations. No previous naming system satisfies this important requirement. The simplicity of the proposed designations is immediately evident from Tables 1 and 2.

2. *Identification of individual viruses by their names.*

The identification of a plant virus by a name of the kind proposed is a very simple matter, and it is equally simple to construct, by the aid of the key, proper names of new viruses according to current knowledge. A list of various potato viruses (Table 2) will demonstrate this. The amount of information provided by the name may be exemplified by potato virus Y, the proposed name of which is *Maphiflexus solani* (Table 2). The generic name describes a virus which is transmissible by leaf-rubbing (M) as well as by aphids (aphi), in which it is nonpersistent (generally suggested by the combination Maphi-); furthermore, the virus has flexible, threadlike particles (flexus). The specific epithet (solani) is derived from the main host and is sufficient to identify the species in question, i.e. potato virus Y and all of its strain. Potato virus A, a closely related virus species, has the same generic name as virus Y, but requires another specific epithet because it is not a strain of virus Y. It is here identified by the name *Maphiflexus sola-alpha*.

Reference to some particular host by the specific epithet serves entirely as a mental association for registration. It is often practical to adopt more

[1]Accepted for publication October 15, 1959. Contribution No. 54 from the Department of Plant Pathology.

Invitational paper, presented at the 43rd Annual Meeting of The Potato Association of America, University of New Brunswick, Fredericton, N. B., Canada, August 1959.

[2]Royal Veterinary & Agricultural College, Virological Laboratory, Rolighedsvej 23, Copenhagen V, Denmark.

TABLE 1.—*Key to descriptive formulary names of plant-infecting viruses.*

Symbols for direct transmission		Symbols for vector transmission		Symbols for virus substances* (particle types)	
M(e)	= mechanical surface transmission to shoots, i.e. by leaf-rubbing method under normal physiological conditions. (M from Lat. *mechanicus*)	in	= virus without specific arthropod vectors. (from Lat. *incognitum* — unknown)	virus	= collective symbol for all types of virus substance, whether known or unknown.
G(e)	= surface-transmission to roots, i.e. infection from contaminated soil. (G from Gr. *ge.* = earth)	aphi	= aphid-borne virus. (from *Aphididae* = aphids)	flexus	= flexible, threadlike particles. (type: potato virus Y)
D(a)	= deeply inoculable only, i.e. by grafting, injection, needle-punctures, etc. to deep-lying tissues. (D from Gr. *dys* = deep)	cica	= leafhopper-borne virus. (from *Cicadina* = cicadellids)	chorda	= rigid, rod-like particles. (type: tobacco mosaic virus)
		x(e)	= virus with multiple arthropod-vectors. (from Gr. *Xenos* = strange)	globus	= small spherical (globular or polygonal) particles with diameter less than 50 mμ. (type: tomato bushy-stunt virus)
		thy	= thrips-borne virus. (from *Thysanoptera*=thrips)	sphaera	= large spherical particles, globes or polygones with diameter more than 50mμ. (type: wound-tumor virus)
		ale	= whitefly-borne virus. (from *Aleurodidae* = whiteflies)	amorphum	= large particles of variable shape. (type: potato yellow-dwarf virus)
		coc	= scale-insect-borne virus. (from *Coccidae* = scale insects)	(........	= others, not yet described or named types of virus substance)
		het	= bug-borne virus. (from *Heteroptera* = bugs)		
		aca	= mite-borne virus. (from *Acarina* = mites)		
		(........	= virus with no described types of arthropod vectors)		

*Each of the defined particle-type symbols involves a certain range of variants. Subdivisions of the initially wide range of these symbols may be undertaken in the future wherever it is found warranted and necessary. (Thus potato virus S particles, which are long needle- or lance-like rods, may be sufficiently different from the chorda type to warrant another type name (e.g. lancea).

TABLE 2.—*A list of various potato-infecting virus species identified by the generic name-formulas (cf. the key) and additional specific epithets.**

in: no arthropod-vector	aphi: aphid-borne	cica: cicadellid-borne	x(e): multiple vectors
Minflexus solani = potato virus X *Minchorda solani-latens* = potato virus S	*Maphiflexus solani* = potato virus Y *Maphiflexus sola-alpha* = potato virus A *Maphiflexus sola-aucuba* = potato virus F-G *Maphichorda solani-latens* = potato virus M *Maphiglobus medicaginis* = potato calico virus	*Mecicamorphum solani* = potato yellow-dwarf virus	*Mexevirus solani* = potato spindle-tuber and unmottled curly-dwarf viruses.
Ginchorda nico-caulis = potato stem-mottle virus *Ginglobus betae* = potato bouquet virus and = potato pseudo-aucuba virus *Ginglobus nico-gamma* = potato ABC-disease virus			
	Daphivirus solani = potato leaf-roll virus	*Dacicasphaera solanacearum* = potato stolbur virus *Dacicavirus callistephi* = potato purple-top virus *Dacicavirus spp.* = potato witches' broom and apical leaf-roll viruses	*Daxevirus spp.* (possible example: potato green dwarf virus ?)

*Lists of references and synonyms, see e.g.: *F. O. Holmes* 1948; *Köhler & Klinkowski* 1954; *K. M. Smith* 1957.

or less of a well-known common name in the latinized epithet, but in reality the identification is independent of the host range.

The identification is also independent of the induced host-symptoms. This may be illustrated by several ranges of completely unrelated viruses which may cause indistinguishable symptoms in potatoes, e.g. potato aucuba mosais virus (F-G) = *Maphiflexus sola-aucuba*, potato pseudo-aucuba virus = *Ginglobus betae*, and potato calico virus = *Maphiglobus medicaginis*. Still another virus type causes the aucuba mosaic of tomato, a strain of *Minchorda nicotianae*.

3. Natural groupings at the generic level without preference for any particular basis of classification.

The generic part of these names is a brief summary of independent fundamental characteristics. Therefore, the generic groups, which are automatically delimited by the combination formulas, are independent of any dispute on the relative importance of the individual characteristics, i.e. whether the particle morphology or the biochemical properties determining the kind of transmission are most essential.

Viruses transmitted by similar methods and apparently of identical particle types possess so many coinciding resemblances that they, in any case, will have to be placed within the same narrow group at the generic level, e.g. the generic name formula *Maphiflexus* delimits a natural group from any point of view. It compiles the following viruses: potato viruses Y, C, A, F-G; henbane mosaic virus; and tobacco etch viruses. All of these are obviously closely related. The genus further includes beet mosaic virus, turnip mosaic virus, and various other virus species sharing many properties and features of behavior in common.

The compilation of the plant viruses into such natural generic groups will greatly simplify comparative and systematic virology. The corresponding name formulas group similar viruses no matter whether they occur in different hosts or in different countries; this can help to put an end to the ever increasing chaos of synonyms

For instance, the majority of known soil-borne viruses affecting the potato plant correspond to one of two generic names, *Ginchorda* or *Ginglobus*. Both describe a kind of soil-borne virus (G) without arthropod vectors (in), but the two kinds of virus have different particle types (chorda and globus, respectively).

The genus *Ginchorda* includes the following local viruses, many of which have several other host and disease-indicating synonyms.

Tobacco rattle virus in Germany (12), Holland (38) and in Denmark (20).
Potato stem mottle virus in Holland (40).
Potato kringerigheit virus in Holland (44).
Potato ring necrosis virus in Scotland (14).
Potato corky ringspot virus in U.S.A. (46).
Wheat rosette virus in U.S.A. (31).
Rotterdam-B virus in Sumatra (45).

Now it is known that at least the five first-mentioned viruses either are identical or are serologically related strains of the same virus species, *Ginchorda nico-caulis;* the specific epithet refers to the first-known disease,

tobacco rattle Tabakmauche (7). Wheat rosette and Rotterdam-B viruses may be separate species of the same genus. If so, they must be designated with individual epithets

The genus *Ginglobus* includes the following:

Tobacco necrosis viruses from England (43) and from several other countries in Europe, America and New Zealand.
Beet ringspot virus in Scotland (25).
Tomato black ring virus in England (41).
Potato bouquet virus in Germany (33).
Potato pseudo-aucuba virus in Germany (34).
Raspberry ringspot virus in Scotland (13).

The tobacco necrosis viruses include three serologically different species (4), which may be distinguished by their specific epithets: *Ginglobus nico-alpha, G. nico-beta,* and *G. nico-gamma* (the last also infects potatoes in Holland, causing the ABC-disease in tubers (35). The next four individually named viruses are shown (26) to be identical or serologically related strains of one species, *Ginglobus betae*, whereas the raspberry ringspot virus represents a different species, *Ginglobus rubi*. The cherry rosette virus (Eckelraderziekte in Holland) is possibly also a strain of one of these species; it is another *Ginvirus*, but its particles have not been seen as yet (37).

The examples show that the generic names possess the virtue of an automatic discrimination or compilation in accordance with true interrelationships and that they suggest comparisons of more or less similar viruses without regard to country, hosts, or symptoms involved.

It should be added, however, that a certain amount of overlapping between generic groups may sometimes occur, although this is relatively rare. Overlapping between well-defined groups occurs in organisms too and presents no objection to the basic concept of the groupings. The cause of overlapping may be evolutionary development by adaptation, which also occurs in viruses. Thus it has been reported in several cases with various insect-borne viruses that the ability to be transmitted by a given vector sometimes ceases after continuous transmission in certain hosts without the aid of the vector (10, 28, 47, 1). Unless the new virus type, originated in this way, is highly contagious by direct contact it will soon cease to exist if the host is not vegetatively propagated. Therefore, overlapping with close relationship between insect-borne and vectorless viruses must be expected most frequently in vegetatively propagated plants like potatoes and fruit trees. Actually this seems to be so.

Cases of overlapping exist between the two genera *Maphichorda* and *Minchorda*, represented by the two potato viruses S (36) and M (2) (Table 2). These show slight serological cross reactions but no cross protection. The vectorless virus S has probably developed from an aphid-borne virus like M by virtue of its better adaptation to the potato plant. This is suggested by the facts that virus S is more latent than virus M and that virus S is the more systemic of the two in King Edward potato plants, being present also in the youngest host tissues which virus M does not invade (39).

A parallel trend of evolution from the genus *Maphiflexus* in the direction of *Minflexus* seems to occur, e.g. the C strain of the potato

virus Y. Potato virus C is serologically and immunologically related to potato virus Y but some cultures of the former are not transmitted by aphids and others are to only a small extent.

Strain C occurs in older potato varieties and does not spread in nature (3), which may suggest that it has developed through adaptation to potato varieties initially infected by a fully aphid-transmissible virus Y. This suggestion appears to be supported experimentally: an aphid-transmitted culture of virus C in tobacco was found to lose its aphid transmissibility when passed through Majestic potatoes (47).

Potato virus A (*Maphiflexus sola-alpha*) may similarly have originated from potato virus Y (*Maphiflexus solani*).The two viruses yield no cross protection, some isolates are slightly serologically related (19), whereas others are not (6). Virus A occurs more or less latent in some older potato varieties and, although still aphid transmissible, it shows little tendency to spread in the field. The host reactions to virus A is most often either latency or top necrosis, which is like certain reactions to virus X (*Minflexus solani*). The sequence of these virus types (Y-A-X) seems to represent stages of an evolution; however, this does not invalidate the clear distinction between the generic groups *Maphiflexus* and *Minflexus*, typically represented by potato viruses Y and X, respectively. That holds true also for others of the generic groups; anyhow, such overlappings are exceptional.

The general rule is that the combination of characteristics, represented by the proposed generic names, discriminates well between relatively closely related and unrelated viruses.

4. The proposed nomenclature system: A neutral tool for identification and for unbiased comparisons of viruses.

As already explained, the generic names will fit in well with any attempt to classify the viruses on particle morphology as well as on the methods of transmission or on properties closely correlated with any of these characteristics.

In any case, names of groups of higher ranks than the generic level may, like generic names, be constructed as formulas; symbol(s) of the criterion or criteria on which attempted groups are based should only be combined with accepted endings, e.g. *-ales* for orders and *-aceae* for families.

Thus the proposed formulary designation offers a simple solution of the problem of clear and easy identification of viruses and placing them into natural groupings (at the generic level), reflecting other characteristics. Moreover, the designation method is indifferent as regards criteria of natural interrelationships but tend to support systematic comparisons as an objective tool. Therefore, to the mind of the author, this method of designation satisfies all reasonable requirements of an internationally acceptable nomenclature of plant viruses.

A similar designation system of animal viruses is equally possible and has already been proposed in outline (22, 23). Clearly defined formulary systems, applied by animal and plant virologists alike, would contribute towards the mutual understanding that is essential if virology is to become a general discipline of natural science

The independence of this nomenclature and classification has been clearly emphasized above. In the following pages the general background of the natural classification will be briefly commented upon in connection with a comparative survey of the four main natural groups of plant viruses.

5. *Definition of a virus, the basis of the natural virus classification.*

Natural grouping is established by nature itself; it is a matter of facts, independent of opinions or tradition. Some virologists still cling to the idea that viruses should be classified primarily on morphology of virus particles, this idea being traditionally connected with classification of plants and animals.

The discoveries of recent years, however, have shown that a virus is not necessarily identical with observable particle (18, 15). Many viruses have not been shown to be associated with particles observable by means of the electron microscope; in some cases, particles of this size may not exist. Virus particles are products of the combined activities of the virus and host cells and may act as a resting stage, but they do not multiply by division like cells. The original definition given in 1898 (8), i.e. a virus is a *contagium vivum fluidum*, is more nearly accurate than all later attempts to define a virus on the basis of obligate parasitism, pathogenicity, size, and chemical composition (5, 32, 11). Notwithstanding the classical and monumental characterization given by Beijerinck, the formulation here presented is believed by the author to represent a close approach to an exact definition.

A virus is a substance—or a combination of substances—with ability to reproduce itself synthetically as an integrating but irregular component of living organisms.

This definition places the viruses between microorganisms, which do not lose their individuality in the act of propagation, and the organismal genes, which are regular components of living cells but have much in common with viruses. The similarity between viruses and genes in respect to chemical composition is very conspicuous, nucleic acids apparently being the essential part of both. This is not stated in the definition, because in the future other substances than nucleic acids may be found to possess the basic properties of a virus. The similarity between a virus and a gene is still more impressive in phenomena like bacterial transformation, transduction and lysogeny, as well as in the somewhat similar phenomenon of the heritable virus in the banana fly, *Drosophila melanogaster* (16, 17, 9, 27).

The common feature in all these phenomena is that normal genetic material may behave like a virus and *vice versa*; a virus may be combined with normal genetic material or be changed into an apparently normal gene. Even in such cases of reversible virus-provirus-gene conditions, the above definition distinguishes clearly between viruses—as irregular—and genes—as regular—agents of similar kinds.

6. *The principle of the natural periodical system of viruses.*

In accordance with the definition of a virus given above, the most determining characteristics of a virus must be its biochemical properties. Particle morphology, if truly determined and not an artifact, is undoubt-

edly important too, perhaps yielding suggestions about the possible routes of evolution of the various viruses. But still, the end results of a polyphyletical evolution converging from different origins may be more closely related biochemically than the end results of a diverging evolution from the same origin. Therefore, as a criterion in the classification of viruses, particle type must be subordinate to biochemical individuality.

Previously, the author has shown that the preferentially affected physiological functions and the associated tissue types are useful indicators of the biochemical properties of viruses .These nature-devised indicators yield an empirical classification by which plant- and vertebrate-infecting viruses are shown to constitute a periodical system of analogous groups, obviously representing true interrelationships within each category. The two categories of viruses are more or less connected through a common main group. As to details reference is made to the previous papers (21, 22, 23, 24). However, here a brief orientation may be added on the actual background of the various ranks of natural virus groups and corresponding practical criteria proposed for their designation.

The plant-infecting viruses are divided into four main groups (called orders), primarily according to their integration into more or less distinct groups of similar biochemical functions as shown by the physiological pathological effects. These effects appear to be connected with the relations to different kinds of arthropod vectors. The four main groups thus delimited are further characterized by a considerable number of correlated properties and a general pattern of behavior (cf. the survey below). All the coincidences indicate that the grouping at this level is a natural one.

Subgroups (called families) within each of the four main groups are characterized by the nature of the virus substances, i.e. by morphology of particles (if any). This criterion possibly reflects common origin from the same group (family). Parallel families within different orders may suggest a common origin with subsequent changes in biochemical properties.

Generic groups are characterized by preferential affinity of the viruses for a particular biochemical environment, represented by one of the three ontogenetically determined tissue regions of the host plant, i.e. superficial tissues in shoot (M) or in root (G) (derived from corresponding dermatogene-periblem) and deep-lying tissues in shoot and root (D) (central cylinder derived from plerom). In practice this regional affinity is approximately correctly disclosed by the ways of direct transmission (cf. M, G, D in the key of symbols). That the generic groups are natural, has already been demonstrated by examples.

Additionally it may be mentioned that animal viruses can be classified in analogous groups: main groups or orders delimited according to the biochemical criterion, namely, the type of physiological host-functions primarily involved; family groups according to particle types, etc.; genera according to the biochemical environment preferentially adopted as indicated by ontogenetical habitat (in ectodermal, entodermal, or mesodermal tissue regions).

The resulting vertebrate virus groups appear to be natural and show important analogies to the parallel plant virus groups (22, 23).

The periodicity of the system of viruses is associated with the onto-

genetical periodicity in the differentiation of higher plants and animals. Both apparently represent a general periodicity of biochemical units, which may be determined by forces similar to those responsible for the periodical system of inorganic elements. In any event, the author (24) has shown that a striking conformity and a number of abstract correlations exist between the periodical system of inorganic elements and the periodical systems of biochemical group-units, i.e. the functional groups of genes (organo-gene) and the functional groups of viruses (the natural virus groups).

7. A comparative survey of typical properties and behavior of plant viruses from the four main groups (orders).

Names of orders (cf. key, table 1): *Invirales, Aphivirales, Cicavirales, Xenovirales.*

I. DOMINANT CHARACTERISTICS.

1. Physiological affinities	*2. Arthropod-vector relations.*
Inv.: Pantropic	No specific arthropod vectors.
Aphiv.: Carbohydrate metabolism	Aphid borne.
Cicav.: Sex-associated functions	Cicadellid borne.
Xenov.: Coordinating functions	Multiple or various odd vectors.

II. HOST-RANGE

Inv.: Plants, not arthropods (G: sometimes nematodes).

Aphiv.: Plants only (with possible exceptions).

Cicav.: In addition to plants, often cicadellids.

Xenov.: In addition to plants, sometimes arthropods (or G: nematodes).

III. SYMPTOMS

1. Physiological.

Inv.: Many functions involved. Balance of infected cells is generally not much disturbed until lethal concentration of the virus is surpassed (see external symptoms).

Aphiv.: Synthesis, mobilization and transport of carbohydrates disturbed. (M) Primary starch-lesions. (D) Starch accumulation, increased osmotic pressure, monosaccharides as transport sugar instead of sucrose.

Cicav.: Abnormal flower-formation; stimulation of tissue growth, apparently sex-hormonal disturbances.

Xenov.: Erroneous orientation, differentiation and growth regulation, apparently disturbance of supreme hormonal system.

2. Histological symptoms.

Inv.: Many types of tissue are involved, often including meristems and pith parenchyma. Often plenty of inclusion bodies in many tissues.

Aphiv.: Assimilation tissues are involved; chloroplast degeneration. Inclusion bodies are scarce or absent. (D): the phloem is often plugged with gum after hypertonic stress and collapses (phloem-necrosis).

Cicav.: Hyperplasia of phloem, with subsequent ulceration (phloem-necrosis), sometimes gall formation. Inclusion bodies may occur but not frequently.

Xenov.: Mutual ratios and orientation of various types of tissue are often disturbed. Visible disturbances often occur in the endodermis-pericycle region of shoot of root. Great variations in presence and number of inclusion bodies.

3. *External symptoms.*

Inv.: In some hosts necrotic local lesions only. Often initial ring and line patterns followed by latency or just latency. Mosaic, distortions ,or other symptoms (cf. pantropism) in many cases

Aphiv.: Hosts reacting with local lesions are not frequent. Mottling type of mosaic of leaves (M) or leaves diffuse yellow and rigid (associated with hypertonic stress and starch accumulation (D)).

Cicav.: Flowers virescent and malformed (phyllody and other abnormalities); often sterility. Vegetative parts with tissue proliferation: witches' brooms, galls etc. Leaves may be green or diffuse yellow.

Xenov.: Malformations and distortions; tissue tensions with fissures; erroneous pigmentation, consistency, flavor, etc.; often severe dwarfing. Leaf-color dark green or yellowish with autumn colors. Often periodic latency with relapse to disease. Sudden death or progressive decline with premature death.

IV. SPECIFIC VIRUS SUBSTANCES.

1. *Dominating particle types.* (as far as known, cf. key of symbols, table 1).

Inv.: Globus, flexus, chorda.
Aphiv.: Globus, flexus, chorda .
Cicav.: Sphaera, chorda, amorphum.
Xenov.: Globus, chorda, sphaera.

2. *Multiplication ability.*(concentration in expressed sap).

Inv.: Generally high.
Aphiv.: Generally moderate.
Cicav.: Generally slow or low.
Xenov.: Great variations, associated with dominating vector type.

3. *Antigenic power.*

Inv.: Antisera often with a high titer.
Aphiv.: Antisera often poor or inavailable.
Cicav.: Antisera as a rule inavailable.
Xenov.: Great variations, associated with dominating vector type.

4. *Purification.*

Inv.: Often easy.
Aphiv.: Often difficult.
Cicav.: Difficult or impossible.
Xenov.: Great variations, associated with dominating vector type.

V. EPIDEMIOLOGY.

1. Virus Sources.

Inv.: Living or dead material contaminated with virus; sometimes soil (G) (or infected nematodes).

Aphiv.: Living virus-infected plants.

Cicav.: Living virus-infected plants or infected cicadellids.

Xenov.: Living virus-infected plants or infected arthopods (or nematodes).

2. Ways of natural infection (transporting agents).

Inv.: Man, domestic and wild mammals, birds, larger insects, and in some cases wind, water, or soil-nematodes.

Aphiv.: Aphids, sometimes (M) additionally like *Inv.*

Cicav.: Cicadellids.

Xenov.: Aphids + cicadellids and/or thrips, white flies, scale insects, bugs, aphids, grasshoppers, earwigs, beetles, or nematodes. Mites especially may be transported by wind (or by riding on insects).

3. Primary conditions for effective natural spread.

Inv.: Superficial or deep wounds in direct contact with contaminated material.

Aphiv.: Simultaneous presence of virus-infected plants and effective aphid vectors.

Cicav.: Infected cicadellid vectors (including those congenitally infected). Infected plants are not absolutely necessary.

Xenov.: Presence of infected plant material only, infected arthropod vectors only, or both together; sometimes wounding and direct contact with contaminated material is sufficient and the primary method of spread.

4. Geographical distribution of natural spread.

Inv.: Often cosmopolitic and following trade-ways; climatic conditions are rarely of any importance.

Aphiv.: Mainly depending on the incidence of aphid vectors. Climatic conditions are often most essential, even within small regions. These viruses seem to prevail in cool temperate zones

Cicav.: Mainly depending on the incidence of cicadellid vectors and on temperature. These viruses seem to prevail in warm temperate zones.

Xenov.: Mainly depending on the dominating agent of transport. Climatic conditions are very important for various subgroups of these viruses (e.g. spread of white-fly-borne viruses occurs mainly in the tropics). In other cases climatic conditions are unimportant.

5. Local incidence.

a) Local conditions for spread.

Inv.: Working methods in handling of plants, transport, etc.

Aphiv.: Seasonal fluctuations in numbers and movements of aphid vectors in relation to exposure of susceptible crops. Distance from local virus sources and aphid centers.

Cicav.: Seasonal movements of cicadellid vectors in relation to susceptible crops exposed. Distance from breeding places of the cicadellids in question.

Xenov.: Depends on dominating transporting agent.

b) Orientation of attacks.

Inv.: Often accidental distribution or orientated according to traffic and/or soil conditions (G).

Aphiv.: Generally centrifugal spread around primary and secondary virus sources.

Cicav.: Attacks often unilateral or along borders with leafhopper invasion from perennial vegetation (clover- and grass-fields, gardens, uncultivated areas).

Xenov.: Depends on dominating transporting agent. Border invasion with most of the various arthropod vectors.

VI. IMMUNOLOGY.

(Frequency of some types of host resistance only considered.)

1. Hypersensitivity.

Inv.: Quite common.
Aphiv.: Not very common.
Cicav.: Rare.
Xenov.: Great variations, associated with dominating vector type.

2. True resistance.

Inv.: Quite common.
Aphiv.: Not very common.
Cicav.: Rare.
Xenov.: Great variations, associated with dominating vector type.

VII. POSSIBLE ORIGIN AND INTERRELATIONSHIPS.

Inv.: Probably often developed from insect-borne viruses by more intimate and pantropic adaptation to host plants. Similar particle types and other features suggest aphid-borne viruses as most frequent ancestors. Other of these viruses may have another origin (various arthropods, nematodes, or their symbiotic microorganisms, perhaps also plant cells), i.e. a polyphyletical evolution is suggested.

Aphiv.: Probably the origin is associated with aphids, e.g. the symbiotic or commensal microorganisms in aphids (perhaps co-responsible for the carbohydrate disposition of aphids). Groups of genes from such cells may be adapted to multiply as irregular components of plant-cell metabolism. Different particle types suggest a polyphyletical evolution from different types of ancestor organisms or cells.

Cicav.: Probably the origin is associated with cicadellids, perhaps with some symbiotic or parasitic egg-transmitted microorganism. The latter may be responsible for the phytotoxic effect of normal leafhopper saliva, which often resembles the effects of these viruses.

Xenov.: Probably the origin is associated with some kind of arthropod vector or its micro-cosmos. Groups of genes from cells of ancestor-organisms may be adapted to multiply as irregular components of the hormone-producing systems in plants. —Viruses in vertebrate animals, with corresponding effects and arthropod relations may be closely related to some of these plant viruses (e.g. if originating from similar symbionts in plant-sucking and blood-sucking mites, bugs, or nematodes.

VIII. CONTROL.

1. *Virus-free plant material for propagation* (tubers, bulbs, scions, etc.)

a) Selection of healthy plants.

Inv.: Inspection is often insufficient. Testing by indicator-plants and/or serologically.

Aphiv.: Inspection of mother crop and progeny; may be supported by testing on indicator plants and in some cases serologically.

Cicav.: As for *Aphiv.* serological testing rarely possible.

Xenov.: As for *Aphiv.*

b) Therapy of infected plants.

Inv.: Sometimes by heat, rarely by meristem cultures (except G).

Aphiv.: Sometimes by heat, often by meristem- cultures.

Cicav.: Often by heat, probably often by meristem cultures.

Xenov.: Often by heat and by simple stem-tip cuttings.

2. *Isolation from virus sources.*

Inv.: Eradication of contaminated material from the area before a new crop is started. Roguing within the crop, if by this further spread may be avoided.

Aphiv.: The greatest possible distance in space or time between new and hibernated crops of susceptible kinds. No roguing when aphids are numerous (if not confined with spraying).

Cicav.: Distance in space or time of new crops from infected plants and especially from breeding places for leafhopper vectors. Roguing appears to be safe.

Xenov.: Distance in space or time of new crops from infected plants and from overwintering places of possibly infected arthropods.

3. *Isolation from transporting agents.*

Inv.: Control of traffic by man and animals; field inspectors should be especially careful. Stock material may be fenced, e.g by wire-netting.

Aphiv.: Local isolation by barrier crops of nonsusceptible plants (cover crops or alternating belts). Stock material in aphid-free districts, as far as possible.

Cicav.: Local isolation by barrier crops applied in bordering belts of larger fields. Small areas may be protected by insect-proof fence.

Xenov.: Local isolation according to dominating transporting agent: e.g. catching belts of susceptible plants for destruction of bugs invading beet fields; in other cases, measure as perhaps for one of the other groups.

4. Chemical control.

Inv.: Disinfection by washing with soap or soap solution, formaldehyde, etc. of workers' hands, clothing and implements. In glasshouses, soil-disinfestation by formaldehyde, etc. or by heating.

Aphiv.: Insecticides (systox, parathion, etc.) applied preferentially to source plants of viruses and to winter resorts of aphid vectors. Precaution with crops for direct consumption.

Cicav.: Insecticides (D.D.T., parathion, etc.) preferentially applied to winter resorts of leafhopper vectors. Precaution when applied to crops especially along field edges.

Xenov.: Insecticides applied according to dominating vector type and crops involved.

5. General crop management.

Inv.: A minimum of uncontrolled handling of plants, especially young ones. (G) Crop rotation with less susceptible crops. Control of perennial weeds.

Aphiv.: Earliest possible spring sowing. Early harvest of tubers, bulbs, etc. Crops for overwintering sown either within cover crops in early spring or at the end of the aphid season. Dense and regularly distributed plant population.

Cicav.: Exposure of susceptible crops as far as possible out of the main season of the leafhopper vector.

Xenov.: According to dominating transporting agent. Exposure of susceptible crops out of the main season for spread by the dominating vector.

SUMMARY

The main point in the proposed system of virus designation is the combination into simple formulas of symbols, standing for essential and mutually independent characteristics. The resulting formulary names are purely descriptive according to current knowledge.

The proposed generic names of plant viruses describe: 1) ways of direct transmission, 2) vector-relations, and 3) particle type. This combination of characteristics discriminates well between different groups of more or less related viruses, which might be called virus genera.

An additional specific epithet of any kind completes identification of the individual virus species. A key of symbols and the corresponding list of names of various potato-infecting viruses is presented.

Besides the identification by name of individual viruses, and the natural grouping at the generic level, the formula system of virus names yields an indifferent tool for unbiassed comparison and compilation of viruses on different criteria.

However, here is presented an exact, general definition of a virus, and the corresponding general principles of the natural periodical system of plant and animal infecting viruses are briefly explained. On this basis is presented a comparative survey of the natural main groups of plant viruses, named as orders in accordance with the formulary system of nomenclature..

Literature Cited

1. Badami, R. S. 1958. Changes in the transmissibility by aphids of a strain of cucumber mosaic virus. Ann. Appl. Biol. 46: 554-562.
2. Bagnall, R. H., R. H. Larson and J. C. Walker. 1956. Potato viruses M, S, and X in relation to interveinal mosaic of the Irish Cobbler variety. Wisconsin Univ. Agr. Expt. Sta., Research Bull. 198: 1-45.
3. Bald, J. G. and D. O. Norris. 1945. Virus C from an old Australian variety of potato. Phytopathology 35: 591-597.
4. Bawden, F. C. 1941. The serological reactions of viruses causing tobacco necrosis. Brit. J. Exp. Path. 22: 59-70.
5. Bawden, F. C. 1950. Plant viruses and virus diseases. 3rd ed. Waltham, Mass 335 p.
6. Bawden, F. C. and F. M. L. Sheffield. 1944. The relationship of some viruses causing necrotic diseases of the potato. Ann. Appl. Biol. 31: 33-40.
7. Behrens, J. 1899. Die Mauche (Mauke) des Tabaks. Landw. Vers.-Stat. 52: 422-447.
8. Beijerinck, M. V. 1898. Ueber ein Contagium vivum fluidum als Ursache der Fleckenkrankheit der Tabaksblätter. Verh. K. Akad. Wetensch. Amsterdam, Sect. 2, deel 6: 1-22.
9. Bertani, G. 1958. Lysogeny. Advances in Virus Research 5: 151-194.
10. Black, L. M. 1953. Loss of vector transmissibility by viruses normally insect transmitted. (Abstr.) Phytopathology 43: 466.
11. Burnett, F. M. and W. M. Stanley. 1959. The viruses. III. Animal viruses. Academic Press; New York-London.
12. Böning, K. 1931. Zur Atiologie der Streifen- und Kränselkrankheit des Tabaks. Z. Parasitenkunde 3: 103-141.
13. Cadman, C. H. 1956. Studies on the etiology and mode of spread of Scottish raspberry leaf curl disease. J. Hort. Sci. 31: 111-118.
14. Cadman, C. H. 1957. The ring necrosis virus of potato. Proc. Third Conf. Potato Virus Diseases, Lisse-Wageningen 1957: 1958: 168-172
15. Cochran, G. W. and J. L. Chidester. 1957. Infectious nucleic acid in plants with tobacco mosaic. Virology 4: 390-391.
16. Ephrussi-Taylor, Harriett. 1955. Current status of bacterial transformations. Advances in Virus Research 3: 275-307.
17. Fredericq, P. 1958. Genetique des bacteriophages. Handb. d. Virusforsch. 4: 27-59.
18. Gierer, A. and G. Schramm. 1956. Die Infektiosität der Nukleinsäure aus Tabakmosaikvirus. Z. Naturforsch. 11b: 138-142.
19. Hansen, H. P. 1937. Studier over Kartoffelviroser in Danmark. Tidsskr. f. Planteavl 42: 631-681.
20. Hansen, H. P. 1946. Undersogelser og Iagttagelser over Tobaksviroser in Danmark. Tidsskr. f. Planteavl 50: 191-298.
21. Hansen, H. P. 1956. Correlations and interrelationships in viruses and in organisms. I. Classification and nomenclature of plant viruses. Den kgl. Veterinaer- og Landbohojskoles Aarsskrift 1956: 108-137.
22. Hansen, H. P. 1957. Correlations and interrelationships in viruses and in organisms. II. The principles of the natural periodical system of plant and animal infecting viruses. Den kgl. Veterinaer- og Landbohojskoles Aarskrift 1957: 31-.66.
23. Hansen, H. P. 1957. The natural periodical systems of organo-genes and viruses as the basis of the practical classification and nomenclature of the viruses. Proc. Third Conf. Potato Virus Diseases, Lisse-Wageningen 1957; 1958: 218-229.
24. Hansen, H. P. 1957. Correlations between the periodical systems of physiologica elements and the periodical system of inorganic elements. Proc. Third Conf. Potato Virus Diseases, Lisse-Wageningen 1957; 1958: 229-232.
25. Harrison, B. D. 1957. Studies on the host range, properties and mode of transmission of beet ringspot virus. Ann. Appl. Biol. 45: 462-472.
26. Harrison, B D. 1958. Relationship between beet ringspot, potato bouquet and tomato black ring viruses. J. Gen. Microbiol. 18: 450-460.
27. L'Heritier, Ph. 1958. The hereditary virus of Drosophila. Advances in Virus Research 5: 195-245.

28. Hollings, M. 1955. Investigations of chrysanthemum viruses. I. Aspermy flower distortion. Ann. Appl. Biol. 43: 86.
29. Holmes, F. O. 1939. Proposal for extension of the binominal system of nomenclature to include viruses. Phytopathology 29: 431-436.
30. Holmes, F O. 1948. Order Virales—the filterable viruses. Bergey's manual of determ. Bacteriology, 6th ed., Baltimore, p. 1126-1286.
31. McKinney. 1925. A mosaic disease of winter wheat and winter rye. U.S.D.A., Dept. Bull. 1361.
32. Klinkowski, M. 1958. Pflanzliche Virologie. I. 267 p.
33. Köhler, E. 1952. Die Bukettkrankheit, eine Viruskrankheit des Kartoffel. Phytopath. Ztschr. 19: 284-294.
34. Köhler, E. and M. Klinkowski. 1954. Viruskrankheiten. Sorauer's Handbook d. Pflanzenkrankheiten, II, 1. Lief. Berlin-Hamburg.
35. Noordam, D. 1957. Tabaksnecrosevirus in samenhang met een oppervlakkige aantasting van aardappelknollen. Tijdschr. O. Plantenz. 63: 237-241.
36. Ouboter, M. P. de Bruyn. 1951. A new potato virus. Proc. Conf. Potato Virus Diseases. Lisse-Wageningen 1951 (1952): 83-84.
37. Pfaeltzer, H. J. 1959. Onderzoekingen over de rozetziekte van de kers. T. Pl. Ziekten 65: 5-12.
38. Quanjer, H. M. 1943. Bijdrage tot de kennis van de in Nederland voorkomende ziekten van tabak en van de tabaksteelt op kleigrond. Tijdschr. o. Plantenziekt 49: 37-51.
39. Rozendaal, A. and D. H. M. van Slogteren. 1957. A potato virus identified with potato virus M and its relationship with potato virus S. Proc. Third Conf. Potato Virus Diseases, Lisse-Wageningen 1957; 1958: 20-36.,
40. Rozendaal, A. and J. P. H. van der Want. 1948. Over de identiteit van het ratelvirus van de tabak en het stengelbontvirus van de aardappel. T. Pl.—Ziekten 54: 113-133.
41. Smith, K. M. 1946. Tomato black-ring: a new virus disease. Parasitology 37: 126-130.
42. Smith, K. M. 1957. Textbook of plant virus diseases. 2nd edit., Churchill, London, 652 p.
43. Smith, K. M. and J. C. Bald. 1953. A necrotic virus disease affecting tobacco and other plants. Parasitology 27: 231-245.
44. Thung, T. H. 1955. Aardappel. Kringerigheit. Instit. Plantenziekt. k. Onderzoek Jaarversl. 1954: 115-116.
45. Thung, T. H. and T. Hadiwidjaja. 1957. Some remarks on Rotterdam-B virus. Proc. Third Conf. Potato Virus Diseases, Lisse-Wageningen 1957; 1958: 233-238.
46. Walkinshaw, C. H. and R. H. Larson. 1958. A soil-borne virus associated with the corky ringspot disease of potato. Nature 181: 1146.
47. Watson, M. A. 1956. The effect of different host plants of potato virus C in determining its transmission by aphids. Ann. Appl. Biol. 44: 599.

CHEMICAL CONTROL OF BLACKLEG, DRY ROT AND VERTICILLIUM WILT OF POTATO[1]

D. B. ROBINSON, G. W. AYERS AND J. E. CAMPBELL[2]

INTRODUCTON

Serious losses in seed potato production in Prince Edward Island occur annually from the diseases blackleg, dry rot and Verticillium wilt. Blackleg (*Erwinia atroseptica*) (van Hall) Jennison) is by far the most important disease of the three. It caused the rejection for seed purposes of more than 5500 acres in the period 1954-1958. Smaller, but consistent, losses are caused each year by dry rot (*Fusarium sambucinum* f.6 Wr. and *Fusarium coeruleum* (Lib.) Sacc.) and by wilt (*Verticillium albo-atrum* R. & B.).

Individual control measures for each of these diseases have been reported previously (1, 8, 9). This paper presents further results obtained over the past four years with various chemicals. In these trials the incitants of the three diseases were present both singly and in combination with each other

MATERIALS AND METHODS

The pathogens used in the trials were isolated from diseased material. The fungi were maintained on potato dextrose agar and the bacteria on nutrient agar. Inocula consisted of a condial or bacterial suspension made from freshly growing cultures, except that in a few cases dry rot inoculum consisted of a suspension of macerated diseased tuber tissue.

All field trials were planted in randomized block designs on land where adjacent plantings had been relatively free of the dry rot, wilt and blackleg pathogens. In most of the trials each treatment comprised 200 plants in a four-replicated block. Seed tubers were obtained from crops known to be free of the diseases under study. The varieties Sebago, Keswick and Irish Cobbler were used. These varieties were chosen because of their differing susceptibility to the pathogens in the tests, as follows:

	Verticillium	*Erwinia*	*F. sambucinum*	*F. coeruleum*
Irish Cobbler	+	+		+
Sebago	+	+	+	
Keswick	+			+

Unless otherwise noted, the seed pieces were sprayed with a suspension of inoculum or were immersed in it; then they were air dried and treated with the desired chemical. Where inocula or chemicals were used in combination, they were kept at the same concentration as when used singly.

Data on the incidence of wilt and blackleg were obtained by counts of infected plants during the growing season. Data on dry rot, unless

[1]Accepted for publication November 9, 1959.
Contribution No. 57, Research Laboratory, Research Branch, Canada Department of Agriculture, Charlottetown, Prince Edward Island.
[2]Plant Pathologist, Plant Pathologist, and Associate Plant Pathologist respectively.

otherwise noted, was obtained by examination of tubers after two to six months in storage. Such tubers were harvested with an elevator digger, bruised on a specially designed platform, and stored in jute sacks at 40-44° F. Dry rot severity was recorded by rating tubers in each treatment lot for number and extent of lesions, weighting and summing the figures and converting to a percentage datum. Percentage data referring to the incidence of any of the diseases under study are presented as an index obtained by the conversion of percentage figures to degrees of an angle as given by Snedecor (10).

A number of the chemicals used were tested for effectiveness in vitro. Filter paper discs were saturated with a solution of the chemical and placed on agar media that had been seeded with one of the pathogens. When the test organism was bacteria, streptomycin assay agar was used, otherwise the assay medium was clarified potato dextrose agar. The comparative effectiveness of chemicals tested in this way was measured by comparing the inhibition zones produced after 12 to 48 hours incubation at 24° C.

The chemical preparations used in these trials, and their active ingredients, were as follows:

Agristrep: streptomycin sulfate 26.7%.

Acid mercuric chloride: 1 qt. hydrochloric acid: 6 oz. mercuric chloride: 25 gals. water.

Agristrep dust: streptomycin sulfate 0.24%.

Agri-mycin 500, 10%: streptomycin sulfate 10%, copper 10%, oxytetracycline 1%.

Agri-mycin 500, 42.4%: streptomycin sulfate 1.755%, copper 42.4%, oxytetracycline 0.176%.

Arasan dust: tetramethyl thiruamdisulphide 50%.

Captan: n-trichloromethylmercapto-4-cyclohexene-1,2 dicarboximide 50% and 75% wettable .

Dithane Z78: zinc ethylene bisdithiocarbamate 65%.

Karathane: dinitro-phenylcrotonate 22.5%, other nitro phenols and derivatives, chiefly dinitrophenol, 2.5%.

Kolo 100: sulfur 75.4%, 2-3 dichloro-1, 4-naphthoquinone 3.5%.

Phygon XL: 2,3-dichloro-1, 4 naphthoquinone 50%.

Spergon: tetrachloro-para-benzoquinone 97%.

Semesan Bel: hydroxymercurinitrophenol 12.5% and hydroxymercurichlorophenol 3.8%.

Sulfuron: sulfur 97%.

Terramine: phenol, coefficient 20.

Lime: equivalent CaO, 74.1%.

Results

Blackleg

Several field trials were carried out with this disease using the variety Sebago. The treatments used and the blackleg control obtained in two such trials are presented in Tables 1 and 2.

TABLE 1.—*Effect of some seed treatment chemicals in controlling blackleg in the variety Sebago.*

Seed treatment[1]	Inoculated Seed		Non-inoculated Seed	
	Percentage non-emergence	Blackleg index	Percentage non-emergence	Blackleg index
Check—no treatment	8.0	18.1	3.5	20.5
Spergon	2.5	18.1	1.5	4.1
Semesan Bel	24.0	17.5	36.5	3.7
Captan 50W	1.5	17.9	3.0	22.1
Mercuric chloride	48.0	2.5	68.5	7.9
Acid mercuric chloride	56.0	3.1	72.5	5.8
Agristrep dust	4.5	0	6.0	0
Agristrep dust + Captan 75W	9.5	0	9.5	0
L.S.D. P.=0.05		6.5		10.8

[1]Application rates: Spergon 1 lb. to 16 gal.; Semesan Bel 1 lb. to 6.25 gal.; Captan 50W 1 lb. to 25 gal.; Mercuric chloride 1 qt. to 25 gal.; acid mercuric chloride 6 oz. HCl, 1 qt. $HgCl_2$ to 25 gal.; Agristrep dust 0.25 per cent streptomycin.

TABLE 2.—*The effect of several fungicides in controlling blackleg in the variety Sebago.*

Seed treatment	Percentage non-emergence	Blackleg index
Check—no treatment	28.4	33.5
Phygon—1 lb./25 gal.	7.2	23.4
Dithane Z78—1 lb./40 gal.	10.6	33.2
Spergon—1 lb./16 gals.	23.2	37.6
Semesan Bel—1 lb./6¼ gals.	6.9	3.5
L.S.D. P=0.05		6.3

In the first trial (Table 1), the treatments were applied to cut seed. Because of unfavorable weather the seed lots had to be held for 36 to 40 hours before planting and under these conditions the mercuric chloride and Semesan Bel treatments markedly reduced the stand. With inoculated seed, treatments containing mercuric chloride or streptomycin significantly reduced disease. With non-inoculated seed, all treatments except Captan 50W significantly reduced blackleg incidence.

In the second trial (Table 2) the seed pieces were contaminated with suspensions made from tubers infected with blackleg and dry rot and the chemical treatments were applied to the whole tubers. Under these conditions Phygon increased the emergence and slightly reduced blackleg incidence whereas Semesan Bel markedly reduced both seed-piece decay and blackleg. Other materials used were ineffective.

In another trial some fungicides were combined with Agristrep (100 ppm streptomycin) in the treatment of inoculated seed. The results, presented in Table 3, show that acidulated mercuric chloride, Semesan Bel

and a combination of Agristrep and Semesan Bel were the only treatments that significantly reduced the diseases. Once again, the mercuric chloride treatment was quite phytotoxic to the seed pieces, reducing emergence. Combinations that included Agristrep gave the best stands.

In two other field trials Terramine, Karathane, Sulfuron dust and liquid, Kolo 100, and hydrated lime have all been found ineffective in controlling blackleg. In these trials, however, the preparations that contained streptomycin at 100 ppm gave moderate control of the disease, especially in the early part of the growing season.

TABLE 3.—*Effect of several seed treatments on emergence and blackleg development in the variety Sebago.*

Seed treatment[1]	Percentage[2] non-emergence	Blackleg index
Check—no treatment	10.0	39.5
Acid mercuric chloride	14.6	10.4
Agristrep + Semesan Bel	2.6	7.4
Agristrep + Captan 50W	1.0	31.0
Agristrep + Spergon	1.0	46.4
Agristrep	5.3	37.8
Captan 50 W	3.6	35.8
Semesan Bel	10.6	22.3
Spergon	19.6	38.6
L.S.D. P=0.05		7.6

[1]Application Rates: as given in Table 1 except that Agristrep was applied as a solution containing 100 ppm streptomycin.
[2]Based on 300 seed pieces per treatment.

Dry Rot and Verticillium Wilt

In previous work (1) Semesan Bel, used as a seed treatment at planting time, was found to give a high degree of dry rot control in potatoes stored from the resulting crop. This finding has been substantiated by subsequent trials over a three year period in which several fungicides have been tested comparatively for dry rot control in parallel trials using the variety Sebago, susceptible to *F. sambucinum* f.6 and the variety Keswick, susceptible to *F. coeruleum*. Semesan Bel has also been shown to be effective in controlling Verticillium wilt (8). In the present work the seed pieces were inoculated with both the dry rot and wilt organisms. Some of the fungicides tested, and their effectiveness in controlling these diseases, are given in Table 4. Seed treatment with mercury compounds invariably gave the best control of both wilt and dry rot but their effect in reducing vigor or stand resulted in a lowered yield in the variety Keswick even though wilt and dry rot were controlled. With this variety the treatments Spergon and Phygon actually increased wilt incidence, and in addition Phygon markedly reduced emergence. In the variety Sebago a high degree of wilt control was given by acid mercuric chloride and this apparently compensated for its phytotoxicity so that there was no reduction in yield.

The direct effect of several fungicides in preventing storage rot in harvested tubers was tested. Control of this disease is particularly important in seed eye-indexing work and in the grading of seed lots because

TABLE 4.—*The effect of some seed treatments on the control of Verticillium wilt and dry rot.*

Seed treatment[1]	Percentage non-emergence	Wilt index	Dry rot index	Plot yield in lbs.
A — Variety Keswick				
Check—no treatment	15.0	26.5	13.0	44.1
Semesan Bel	9.7	2.3	4.6	51.3
Captan 50W	7.4	24.6	10.2	61.2
Spergon	4.1	33.1	14.5	52.5
Phygon	29.7	37.6	12.4	28.0
Dithane Z78	10.6	40.2	11.9	41.4
L.S.D. P=0.05		11.1	4.5	11.2
B — Variety Sebago				
Check—no treatment	0.3	29.2	14.0	
Semesan Bel	0.9	3.5	4.0	
Acid mercuric chloride	11.9	0.0	2.1	
Agri-mycin 500 (42.4% Cu)	0.3	32.3	11.0	
L.S.D. P=0.05		8.2	7.1	

[1]Application Rates: Semesan Bel 1 lb./6.25 gal.; Captan 50W 1 lb./25 gal.; Spergon 1 lb./16 gal.; Phygon 1 lb./25 gal.; Dithane Z78 1 lb./40 gal.; Acid mercuric chloride 6 oz. HCl, 1 qt. $HgCl_2$/25 gal.; Agri-mycin 500—2400 ppm copper, 100 ppm streptomycin.

in these operations there is abundant opportunity for infection of cuts and bruises by *Fusarium* with resultant severe losses during the subsequent storage period. Two trials were carried out.

Trial 1. Sebago tubers, each with an eye excised for indexing were surface inoculated with a spore suspension of *F. sambucinum* f.6, allowed to drain, then treated with a fungicide either by dipping in a solution or dusting the cut surface. The dry rot incidence after the storage period was as follows:

Tuber treatment	Dry rot index
Check—no fungicide	69.8
Agri-mycin 500 (10% Cu) — 60 ppm Cu : 60 ppm streptomycin	75.1
Captan (50% W) — 1 lb./25 gal.	64.4
Arasan (50% dust) — to cover cut surface	63.6
Captan (7% dust) — to cover cut surface	61.3
Semesan Bel — 1 lb./6.25 gal	36.9
Agri-mycin 500 (42.4% Cu) — 2400 ppm Cu : 100 ppm streptomycin	19.8
L.S.D. P=0.05	4.9

Semesan Bel, and Agri-mycin 500 containing 42.4 per cent copper, gave a high degree of dry rot control with no inhibition of subsequent sprouting although Agri-mycin wes slightly phytotoxic as indicated by some pitting of the tuber surfaces. The other materials were relatively ineffective in controlling rot.

Trial 2. Whole tubers and cut seed respectively were inoculated with a spore suspension of *F. sambucinum* f.6, then treated with Semesan Bel and held in storage at 40° F. At the end of five months an examination for dry rot showed that considerable fungal and bacterial rot had occurred in the cut seed but that the whole tubers were unaffected. These whole tubers, when cut into seed pieces, began to develop dry rot whereas seed pieces cut from inoculated, Semesan Bel-treated tubers remained sound and plots planted with them developed uniform stands with complete plant emergence.

Combined Fungicidal-Bactericidal Treatments

Verticillium wilt, blackleg and dry rot often occur together in potato fields and a seed treatment designed to control any one may not be effective against the others. Attempts were therefore made to control these three diseases simultaneously by combinations of a bactericide and fungicide. In field trials, seed lots of the variety Sebago were inoculated singly and in all combinations with the respective pathogens. A bactericide and fungicide were then used singly and in combination on half of each inoculated seed lot with suitable untreated and uninoculated checks included. Two separate trials were carried out, one in 1957 with Agristrep and Captan 50W, the other in 1958 with Agristrep and Semesan Bel.

Trial 1. Agristrep, (100 ppm streptomycin) and Captan 50 per cent wettable, at 3 pounds per 100 gals. water, were used. Dry rot inoculum was applied as a suspension of macerated, dry rotted tubers taken from storage. This inoculum incited a high incidence of bacterial decay in the seed pieces and this was augmented by the addition of blackleg bacterial suspensions. Dry rot and wilt development was slight in both treated and untreated lots so that the effects of seed treatments were inconclusive. The chemicals, alone or in combination, did not significantly control blackleg except in the case where blackleg and dry rot inoculum were applied together on the seed pieces. This combination resulted in 44.2 per cent blackleg, but when such seed was treated with a mixed suspension of Agristrep and Captan the incidence of blackleg was reduced to 22.6 per cent.

Trial 2. Agristrep, (100 ppm streptomycin) and Semesan Bel were used and all inoculum consisted of pure culture suspensions of the pathogens. In this trial there was no appreciable seed piece decay. Emergence was uniformly high in all treatments, with a high incidence of wilt and moderate dry rot and blackleg development. Some of the inoculum and treatment combinations and their effects are given in Table 5. In no case was there any statistical evidence that combinations of inoculum increased the incidence of any disease. Significant control of wilt and dry rot was given by Semesan Bel and of blackleg by Agristrep. Diseases caused by combinations of bacterial and fungal inoculum were controlled by combinations of the bactericide and fungicide.

Tests in vitro, using the assay plate technique (Fig. 1), generally supported these findings. Growth of *E. atroseptica* was suppressed by materials containing streptomycin or mercury but not by Spergon, Phygon or Captan 50W. *F. sambucinum* was inhibited by mercury compounds and by Agri-mycin 500 (42.4 per cent copper) but was not affected by Spergon,

TABLE 5.—*The effect of Agristrep and Semesan Bel on the incidence of dry rot, blackleg and Verticillium wilt.*

A — Dry rot

Inoculum[1]	Seed treatment[2]	Dry rot index
F	none	9.4
EF	none	13.8
FV	none	11.5
EFV	none	7.8
F	Semesan Bel	3.1
EFV	Semesan Bel + Agristrep	3.1
L.S.D. P=0.05		4.9

B — Wilt

Inoculum[1]	Seed treatment	Wilt index
V	none	49.2
EV	none	45.6
FV	none	41.7
EFV	none	46.6
V	Semesan Bel	7.7
EFV	Semesan Bel + Agristrep	13.8
L.S.D. P=0.05		6.7

C — Blackleg

Inoculum[1]	Seed treatment	Blackleg index
E	none	13.0
EV	none	13.1
EF	none	10.4
E	Agristrep	3.3
EFV	Agristrep + Semesan Bel	0.0
L.S.D. P=0.05		8.4

[1]Suspensions of: E—*Erwinia atroseptica*, F—*Fusarium sambucinum*, V—*Verticillium albo-atrum*.

[2]Application Rates: Semesan Bel, 1 lb/6.25 gal.; Agristrep, 100 ppm streptomycin.

Phygon, Captan 50 W or streptomycin preparations. *V. albo-atrum* reacted similarly to *F. sambucinum* except that slight inhibition was exerted by Captan 50W and Phygon. In some of this work, the filter paper discs were impregnated with combined suspensions of materials and plates seeded with combinations of the organisms. No additive inhibitory effects were observed to result from this, the materials apparently acting independently of each other.

Agrimycin 500, in a solution containing 100 ppm streptomycin and 2400 ppm copper, was tested in a greenhouse planting with Sebagoes in which seed pieces were inoculated with a combination of wilt and blackleg inoculum. Some individual control of each disease was achieved but the Agrimycin was again somewhat phytotoxic, reducing the vigor and growth of the plants. It was of interest that, under these conditions, blackleg incidence was 24.8 per cent when a combined inoculum was used, but only 9.0 per cent when blackleg inoculum alone was used, suggesting that reduced vigor may have predisposed the plants to blackleg infection.

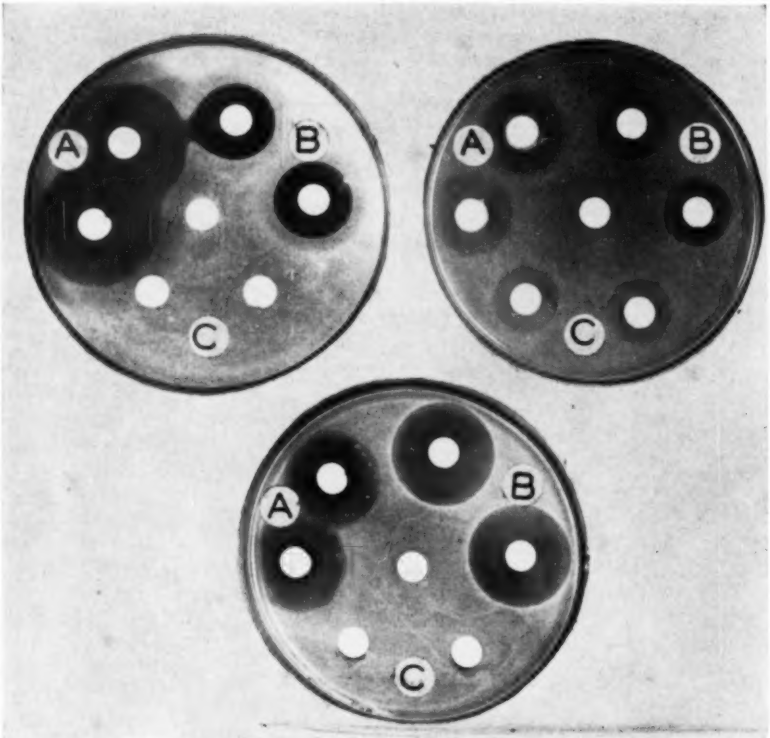

Figure 1.—Comparative inhibition in vitro given by A—Semesan Bel; B—mercuric chloride (1:1000); C—Agristrep (100 ppm streptomycin). Pairs of paper discs saturated with the respective chemical were placed on agar seeded with: upper left—*F. sambucinum* f.6, upper right—*E. atroseptica*, lower—*V. albo-atrum*. Center disc on each plate saturated with water.

Discussion

Seed treatment is by no means general practice in many potato growing areas. In a recent survey (6) it was found that only a few locations in Canada and the United States had more than 50 per cent of the acreage treated, and in many of the major potato producing areas little seed treatment is being carried out. Where seed-borne bacterial or fungal diseases are not a serious problem there seems to be little evidence that seed treatment is beneficial. In trials in western Washington with many of the common fungicidal seed treatment chemicals, under conditions where seed piece decay was not encountered, none of the treatments gave consistently improved stands (5). On the other hand, seed or tuber treatment has proven very beneficial in certain localities and against certain diseases, notably for bacterial seed-piece decay and blackleg in Maine (2), for

Fusarium seed-piece decay in Long Island (3) and for Fusarium storage rots in Long Island and Great Britain (3, 4).

In the present work significant control of blackleg, dry rot and Verticillium wilt has been achieved with seed treatments. In most trials, moderate to good control of blackleg was given by mercuric chloride or Semesan Bel. In some cases this control was more than offset by phytotoxic effects that reduced plant emergence (Table 1). Such injury was accentuated when unfavorable weather forced a delay in planting. Agristrep, applied to give 100 ppm streptomycin, gave some control of blackleg except in one instance (Table 3). In this case it is notable that a combination of Agristrep and Semesan Bel controlled blackleg very effectively and that this combination was also very effective in later tests (Table 5) where both fungal and bacterial inoculum were present. It is noteworthy that Agristrep usually promoted emergence and gave good control of blackleg early in the growing season but that its protection apparently lessened with time so that considerable blackleg often developed in August and September.

Of the materials tested, only Semesan Bel and mercuric chloride gave effective control of seed-borne *Fusarium* or *Verticillium*. Semesan Bel and Agri-mycin 500 (42.4 per cent copper) gave the best control of Fusarium rot in stored tubers. Phygon seriously reduced emergence and yield in the variety Keswick (Table 4) whereas Captan increased stand and yield. Neither material gave effective disease control. In these trials the ineffectiveness of Arasan, Spergon and Dithane Z78, as contrasted with the effectiveness of an organo-mercury material, is in agreement with other reports (4, 7).

There is some evidence that more blackleg develops when the seed pieces are contaminated with a combined inoculum than when the blackleg organism is present alone. This trend was clearly present in only one year in field trials but nevertheless points to the possibility that fungal or other organisms present on the seed piece may predispose the plant to attack by *E. atroseptica*. This would explain the apparently contradictory results occasionally obtained. For example, Spergon was ineffective in controlling *Fusarium* rot and blackleg (Tables 1, 2 and 3) where the blackleg organism was present alone or in combination with *Fusarium*, but Spergon effectively controlled a natural epidemic of blackleg in one test (Table 1) where non-inoculated seed was used. In this case it may be that seed-borne organisms were suppressed that, if unchecked, would have predisposed the plants to infection by blackleg bacteria. Similarly, the effectiveness of Semesan Bel in controlling blackleg may depend to some extent on its fungicidal activity in addition to its considerable bactericidal action.

Captan solutions proved relatively ineffective against all three diseases. Combinations of Captan and Agristrep also gave no control of seed piece decay and blackleg except in one instance where dry rot and blackleg inoculum were present together on the seed pieces. Here again the fungicidal action of Captan may have indirectly controlled blackleg by suppressing fungal invasion, thus reducing infection courts for the blackleg pathogen.

In general, Semesan Bel has proven in these trials to be the best all-round seed treatment chemical. It was consistently effective against

dry rot and wilt and partially so against blackleg, but under sub-optimum planting conditions its phytotoxicity oftimes reduced its value. Greater effectiveness, and a more widespread use, of seed treatment in potatoes will probably follow the development of a material of low phytotoxicity having both fungicidal and bactericidal properties. Progress may also come through the use of a fungicide on whole tubers during storage followed by a bactericide on seed pieces applied at time of planting.

Summary

A number of chemical proprietary compounds were tested for the control of blackleg, dry rot and Verticillium wilt in potato. In most, but not all instances, blackleg was controlled by treatment of seed pieces with mercuric chloride, Semesan Bel or Agristrep. Phygon, Spergon, Dithane Z78, Captan, Terramine, Karathane, Sulfuron, Kolo 100, and Lime gave little or no control.

Dry rot and Verticillium wilt originating in seed stocks were controlled by seed treatment with Semesan Bel and acid mercuric chloride. Captan, Spergon, Phygon, Dithane Z78 and Agri-mycin 500 proved ineffective. Dry rot in stored potatoes was most effectively controlled by tuber treatment with Semesan Bel or Agri-mycin 500 (42.4 per cent copper).

Combinations of two or more of these diseases were controlled by Semesan Bel alone and by combinations of Semesan Bel and Agristrep, but not by combinations of Captan and Agristrep. Pronounced phytotoxicity always followed treatment with mercuric chloride, and occasionally followed treatment with Semesan Bel, but under good cultural conditions Semesan Bel gave marked disease control and did not adversely affect stands.

Literature Cited

1. Ayers, G. W. and D. B. Robinson. 1956. Control of Fusarium dry rot of potatoes by seed treatment. Am. Potato J. 33: 1-5.
2. Bonde, Reiner and Paulo de Souza. 1954. Studies on the control of potato bacterial seed-piece decay and blackleg with antibiotics. Am. Potato J. 31: 311-316.
3. Cunningham, H. S. and Otto A. Reinking. 1946. Fusarium seed piece decay of potato on Long Island and its control. N. Y. Agr. Exp. Sta. Bull. 721.
4. Foister, C. E., A. R. Wilson and A. E. W. Boyd. 1945. Control of dry rot of seed potatoes by dusting. Nature 156: 394-395.
5. Gould, C. J. and T. E. Randall. 1950. Potato tuber disinfection tests in western Washington. Am. Potato J. 27: 249-256.
6. Hoyman, W. G. 1957. Potato seed treatment. In Potato Handbook. Disease Control Issue. Vol 2: 13-17. The Potato Association of America.
7. Lutz, J. M. 1953. Fusarium tuber rots of late potatoes as related to injuries and certain chemical treatments. Am. Potato J. 30: 131-134.
8. Robinson, D. B. and G. W. Ayers. 1953. The control of Verticillium wilt of potatoes by seed treatment. Can. J. Agr. Sci. 33: 147-152.
9. Robinson, D. B. and R. R. Hurst. 1956. Control of potato blackleg with antibiotics. Am. Potato J. 33: 56-59.
10. Snedecor, G. W. 1946. Statistical Methods. Iowa State Coll. Press. 4th ed.

NEWS AND REVIEWS

SUPPLEMENTARY LIST OF INTERNATIONAL POTATO RESEARCH PROJECTS

POTATO ASSOCIATION OF AMERICA

INTERNATIONAL RELATIONS COMMITTEE 1960

AFRICA

SOUTHERN RHODESIA

BRANCH OF BOTANY AND PLANT PATHOLOGY, FEDERAL MINISTRY OF AGRICULTURE, P. O. BOX 8100, CAUSEWAY, SALISBURY, SOUTHERN RHODESIA

G. R. Bates

FUNGUS DISEASES — Late Blight—races, field resistance.

BACTERIAL DISEASES — Bacterial wilt—*Pseudomonas solanacearum*—races.

ASIA

INDIA

CENTRAL POTATO RESEARCH INSTITUTE, SIMLA (PUNJAB), INDIA

SECTION OF GENETICS

Pushkarnath (Director)

BREEDING and *GENETICS* — Disease resistance—late blight.

VIRUS DISEASES — Survey and assessment of virus diseases of commercial crops, susceptibility tests and production of disease-free foundation stocks.

M. L. Khanna

BREEDING — Clonal selection of earliness, drought and frost resistance.

D. Srinivasachar

CYTOGENETICS — Interspecific hybridization; cytology.

K. P. Sharma

BREEDING — General breeding and inbreeding studies.

R. S. Dwivedi

CYTOGENETICS — Incompatibility and embryological studies.

SECTION OF PLANT PATHOLOGY

B. L. Dutt

FUNGUS DISEASES — *Phytophthora infestans*, strains, resistance, and chemical control.

Alternaria solani, strains, chemical control.

Sponospora subterranea, varietal resistance, control methods.

S. G. Phadtare

FUNGUS DISEASES — With reference to wilt diseases.

SECTION OF PLANT PHYSIOLOGY

Rajat De

PHYSIOLOGY — Nutrition with reference to micro-elements, dormancy, quality.

Raghbir Singh

PHYSIOLOGY — Nutritional requirements of potato varieties with respect to potash and phosphorus.

POTATO RESEARCH STATION OF CENTRAL POTATO RESEARCH INSTITUTE, PATNA (BIHAR), INDIA

SECTION OF BOTANY

M. J. Deshmukh

BREEDING — General breeding and resistance to charcoal rot (*Macrophomina phaseoli*).

S. K. Anand
BREEDING — Clonal variations.

SECTION OF PLANT PATHOLOGY

K. D. Paharia
FUNGUS DISEASES — *Macrophomina phaseoli*, aetiology and control.
BACTERIAL DISEASES — Brown rot (*Pseudomonas solanacearum*), varietal resistance.

SECTION OF ENTOMOLOGY

K. K. Nirula
INSECTS — Aphids, cut-worm, tuber moth, Epilachna; their survey and methods of control.

SECTION OF AGRICULTURAL CHEMISTRY

K. Swaminathan
PHYSIOLOGY — Nutritional requirements of potato with respect to micro-nutrients; industrial use of potato.

POTATO BREEDING & SEED CERTIFICATION, KUFRI, OF CENTRAL POTATO RESEARCH INSTITUTE, SIMLA (PUNJAB), INDIA

L. C. Sikka
BREEDING — General breeding; combining ability to commercial varieties and hybrids; rate of mutability.

B. L. Barua
BREEDING — Genetics, resistance to charcoal rot.

POTATO SEED MULTIPLICATION STATION (OF CENTRAL POTATO RESEARCH INSTITUTE) MUKTESWAR, KUMAON HILLS, U. P., INDIA

M. B. Patkar
VIRUS DISEASES — Maintenance and production of virus free foundation stocks.

REGIONAL POTATO EXPERIMENTAL AND TRIAL CENTRES (OF CENTRAL POTATO RESEARCH INSTITUTE), BABUGARH, (UTTAR PRADESH), JULLUNDUR, (PUNJAB), OOTACAMUND, (MADRAS), INDIA

Pushkarnath (Co-operative workers M. L. Khanna, Rajat De, M. J. Deshmukh, M. D. Azariah, Pritam Singh, G. T. Chahabria)
Varietal adaptibility test; cultural and manurial requirements of varieties.

INDIAN AGRICULTURAL RESEARCH INSTITUTE, NEW DELHI 12, INDIA

DIVISION OF BOTANY

M. S. Swaminathan
INDUCTION OF MUTATIONS IN POTATO.

JAPAN

MINISTRY OF AGRICULTURE, BUREAU OF AGRICULTURAL IMPROVEMENT, KASUMIGASEKI, CHIYODAKU, TOKYO, JAPAN

SECTION OF PLANT PROTECTION

M. Hori
FUNGUS DISEASES — Late blight—oospore formation.

AUSTRALIA

DEPARTMENT OF AGRICULTURE, N.S.W. DIVISION OF PLANT INDUSTRY, P. O. BOX 36, FARRER PLACE, SYDNEY, AUSTRALIA

R. J. Jessup
BREEDING — Resistance to late blight, scab, virus X.
Improvement of yield and quality.

EUROPE

GERMANY

KARL-MARX-UNIVERSITAT, LEIPZIG, ABTEILUNG LANDWIRTSCHAFTLICHE, BOTANIK AM INSTITUT FUER PHYTOPATHOLOGIE, FICHTESTRASSE 28, EASTERN GERMANY

G. Schuster

VIRUS DISEASES — Biochemical virus research; chemical diagnosis.

ITALY

UNIVERSITY OF BARI, INSTITUTE OF PLANT PATHOLOGY, VIA SALERNO 165A, BARI, ITALY

Antonio Ciccarone

FUNGUS DISEASES — Late blight—culture and races.

NORTHERN IRELAND

GOVERNMENT OF NORTHERN IRELAND, MINISTRY OF AGRICULTURE, THE MANOR FARM, LOUGHGALL, CO. ARMAGH, NORTHERN IRELAND

PLANT BREEDING DIVISION

K. G. Proudfoot

POTATO BREEDING PROJECTS — DISEASE RESISTANCE

Potato root eelworm. (*Heterodera rostochiensis*)
Potato blight (*Phytophthora infestans*)
Common scab (*Actinomyces scabies*)
Dry rot (*Fusarium* spp.)
Viruses X, A, B, C, and Y

SOUTH AMERICA

BRAZIL

ESTACAO EXPERIMENTAL DE HORTICULTURA, DOMINGOS PETROLINI, RIO GRANDE-RGS, BRAZIL

Floriano Fernando Guimaraes
Ney Kremer Luz
C. A. Rodrigues da Nova Cruz

BREEDING — *Phytophthora infestans*, *Pseudomonas solanacearum* and *Alternaria solani.*

FUNGUS DISEASES — *Phytophthora infestans*, strains and chemical control Fusarium sp. (dry rot).

BACTERIAL DISEASES — *Pseudomonas solanacearum*. Hosts and control.

In attending to his many civic and business affairs, Edmunds finds that a neat and efficient office is a necessity.

Rohm & Haas field representative Bill Hughson joins Edmunds in a look at one of the water hazards on the new golf course.

Edmunds checks proper dosage of DITHANE M-22 *as McQuade fills sprayer. Both like the easy mixing of this 80% maneb fungicide.*

Edmunds discusses his DITHANE M-22 *needs with Raymond Howard, Manager of the John Watson Co. store at Fort Fairfield.*

Maine's E. Perrin Edmunds certified seed potato crop

DITHANE M-22 ... now 80% maneb ... from your partner in crop protection

DITHANE *is a trademark, Reg. U.S. Pat. Off. and in principal foreign countries.*

Judy, 5, and "Mike", 8, join their father on the front steps of the family home in Fort Fairfield. Pet Siamese cat, "Sim", relaxes while German Shepherd, "Ears", shows how he got his name.

Potato farmer-businessman E. Perrin Edmunds instructs farmhand Henry McQuade which field to spray next in his continuing potato blight control program.

prevents blight on his with DITHANE M-22

E. Perrin Edmunds, Fort Fairfield, Maine, recently ended his third term as president of the National Potato Council.

He is typical of today's progressive farmer—active community, state and national leader, successful businessman, and hard-working farm manager.

Currently, he is also a bank director, member of the State Legislature, president of C. A. Powers & Co., the John Watson Co., and Powers Starch Co., and building committee chairman for the local country club . . . now working on a new 18-hole golf course on which Edmunds will somehow find time to play.

Potatoes thrive on 700 of the rolling acres which make up the C. A. Powers & Co. potato operation. The crop is sold as certified seed. Culls and rejects are diverted to the company's potato starch plant located in Monticello, Maine.

Like most of his fellow potato growers, Edmunds puts his faith in DITHANE M-22 (maneb) fungicide for protection from early and late blight.

Chemicals for Agriculture

ROHM & HAAS COMPANY

WASHINGTON SQUARE, PHILADELPHIA 5, PA.

RESULTS OF 1959 FUNGICIDE AND NEMATOCIDE TESTS

The "Results of 1959 Fungicide and Nematocide Tests" is now available. This report is issued annually by the American Phytopathological Society Advisory Committee on Collecting and Disseminating New Fungicide Data. This report serves as a medium for organizing and presenting the summarized results of current fungicide and nematocide testing projects. Much of the information is never otherwise published or made conveniently available. Information on products available for testing, composition of products and their sources are given.

The Committee is anxious to receive reports from all investigators in the field of fungicide and nematocide testing. A copy of the report is provided all cooperators. Submit reports to A. B. Groves or F. H. Lewis not later than January 1, 1961. Reporting forms will be provided upon request. Copies of this report are available at $1.00 per copy when accompanied by a remittance, $1.25 when invoiced and billed. Address orders *to A. B. Groves, Winchester Fruit Research Laboratory, Route 3, Winchester, Virgnia. Make remittances payable to the American Phytopathological Society.*

VEGETABLE DISEASES AND THEIR CONTROL

Professor Emeritus Charles Chupp and Prof. Arden F. Sherf of the plant pathology department at the State College of Agriculture, Cornell, are co-authors of a new book "Vegetable Diseases and Their Control," published this month by the Ronald Press.

Pertinent facts about the history, causes, and symptoms of vegetable diseases in temperate and tropical climates are given, and the weather conditions that hinder or favor them are recorded in detail. Because mineral deficiencies in soils often produce crop symptoms which closely resemble diseases, the authors discuss such deficiencies fully and describe their effects. A discussion of nematodes and current practices in soil sterilization are also included.

Professor Chupp is considered a world authority on vegetable diseases. He taught more than 40 years at Cornell, including 27 as professor of plant pathology. Dr. Chupp became professor emeritus in 1954.

Professor Sherf taught plant pathology and served as Extension plant pathologist at the University of Nebraska and Iowa State University before coming to Cornell as professor of plant pathology and Extension plant pathologist in 1954. He is project leader for all phases of Extension work pertaining to plant pathology in New York, and specializes in vegetable diseases.

Profs. A. Frank Ross, William F. Mai, A. G. Newhall, and Professor Emeritus Walter H. Burkholder, of the Plant Pathology Department and Prof. William C. Kelly of the Vegetable Crops Department assisted in preparing the manuscript.

POTATO FLAKES IN CANADA

A plant producing instant mashed potato flakes in a unique process has been put on a 24-hour shift, producing more than one 48-package per minute. Operated by Salada-Shirriff-Horsey Ltd., international food marketer at Alliston, Ontario, it is Canada's first such plant.

Started in the spring of last year, the $1,000,000 plant is equipped to store 15,000,000 pounds of potatoes at one time. About 100 persons are employed in the highly technical and mechanized "flaking" process.

Shirriff Instant Mashed Potato Flakes are tissue-thin flakes of dehydrated potatoes that are quickly reconstituted into natural mashed potatoes by blending with milk and water. The potatoes have been mashed and cooked before conversion.

Grant Horsey, president of Salada-Sheririff-Horsey Ltd., said the company looks forward to being able to establish similar potato flake plants in other major potato growing regions of Canada.

USDA SCIENTISTS DEVELOPING "INSTANT" SWEETPOTATOES

"Instant" sweetpotatoes are now ready for the pilot-plant stage of development, the U. S. Department of Agriculture reported recently. Officials emphasized, however, that additional research and development work remain to be done before such products will be in commercial production or available to consumers.

Agricultural Research Service scientists report that instant sweetpotato flakes, prepared in the laboratory by a process similar to that developed by the Department and used in manufacturing instant white potato flakes, have the characteristic bright color as well as the flavor of fresh pureed sweetpotatoes. When added to hot water or milk, the flakes are ready in 60 seconds to eat as mashed sweetpotatoes or for use in a pie or casserole, seasoned and garnished as preferred.

Two major problems remaining to be solved to make instant sweetpotatoes commercially feasible are (1) process engineering and (2) flavor stabilization during storage. The first of these will be worked out in a new sweetpotato processing pilot plant now under construction at New Orleans. The pilot plant, financed from funds made available by the Congress specifically for sweetpotato research, will use a modification of the process developed by Department scientists for making instant white potato flakes.

Oxygen appears to be the greatest contributor to flavor changes in the sweetpotato flakes, Department scientists reported, and packaging in nitrogen or some other inert gas may insure flavor stabilization. Samples of instant sweetpotato flakes made in the laboratory and packaged in nitrogen gas, much the same as some coffee is now packaged, have retained full flavor for more than a year, while flakes packaged in ordinary atmosphere deteriorated in a few weeks.

The new sweetpotato processing plant in which pilot plant studies will be carried on, is scheduled for completion by harvest time for the 1960 sweetpotato crop. When the plant gets into operation, the Department plans to produce enough of the instant sweetpotato flakes for consumer testing, probably late this year or early in 1961.

Additional Background

Although final details of the engineering processes for making instant sweetpotatoes remain to be worked out, chemists of the ARS Southern Utilization Research and Development Division at New Orleans reports that the sweetpotatoes, known as yams throughout much of the Nation, must be washed, preheated in warm water, peeled, trimmed, cut into pieces, and cooked. The cooked cut sweetpotatoes are made into a puree and dried in thin sheets on a continuous drier. As the sheets of cooked and dried puree come from the drier they may be broken up and packaged.

When and if commercial processing procedures are finally developed and instant sweetpotatoes are ready for consumer marketing, they may be packaged either as flakes or ground to increase the product's bulk density, say Department scientists. Grinding of the sweetpotato flakes does not change the flavor or texture of the reconstituted product but it might prove

desirable in bulk packaging for institutional use. This advantage may not, however, justify the cost of grinding.

Commercial development and marketing of instant sweetpotatoes, say Department officials, could help restore this crop to its former place in agriculture. Production in 1957, for example, was only about 36,000,000 bushels as compared with about 75,000,000 bushels in 1944. Farm income from sweetpotatoes during these years also dropped off substantially.

The new instant sweetpotato products probably will be made from oversized and malformed sweetpotatoes, which account for between 30 and 50 per cent of the annual yields. These lower grades are always difficult to market because of their size and shape, but in flavor and food value they are equal to No. 1 sweetpotatoes. They might therefore be found suitable for use in manufacturing the new "instant" products.